ON-BOARD DIAGNOSTICS
REMOTE SENSING DEVICE

GENERATION - ONE

BEGINING IN 1980 - CALIFORNIA

1981 - FEDERAL/HIGH ALTITUDE
(FEDERAL - 49 STATES, HIGH ALTITUDE - 4000 FT OR 1200 METERS)

GENERATION - TWO

CALIFORNIA - 1994

FEDERAL - 1996
(HIGH ALTITUDE INCLUDED WITH FEDERAL)

David H. Lee
13 Cathy Lane
Aston, PA 19014

The Role Of Onboard Diagnostics (OBD)

In Performing Emission Repairs

When a vehicle's fuel management (emission control) computer detects an abnormally occurring condition, it will set a fault code and possibly either (1) illuminate a malfunction indicator (check engine) light, or (2) alter its own fuel management or emission control strategy, or both. These fault codes are the computers only means of communicating that some type of problem has been detected. Fault codes-or conditions under which they are set-vary from manufacturer to manufacturer and from model to model. The process of setting a fault code and illuminating a light is referred to as onboard diagnostics or OBD.

The original intent of these fault codes was to inform the automotive engineers initially designing the system, that a set of undesirable conditions had occurred. As is the fate of all leftover development tools, they became employed as part of the assembly-line test equipment and quality control processes. The term ALDL or Assembly Line Diagnostic Link was first used by GM in the early '80's to describe their interface to the fuel/emission control computer. The use of this diagnostic port and the reliance on the vehicle's computer to perform its own self diagnosis, increasing became a more essential part of the recommended factory service procedures. Ascertaining that the fuel/emissions control computer has detected an abnormal condition is fundamental in resolving any vehicle problem.

OBD will play two essential roles in improving our nation's air quality: (1) as an inspection tool and (2) as a diagnostic and repair tool. As an I/M inspection tool, thus far it has been a disappointment; on the other hand, as a diagnostic and repair tool, it has been an outstanding success. Its failure as an inspection tool is a result of the variety of methods employed by the different vehicle manufacturers in setting OBD codes, retrieving OBD codes, and in illuminating a malfunction indicator light or check engine light when certain codes are set. For example, on some systems;

- Codes are cleared (erased) if the ignition is cycled on and off.
- A check engine light may be illuminated as a service reminder.
- The nomenclature appearing on the malfunction indicator lights is inconsistent, even within a manufacturer's models. Various descriptions include "Check Engine", "Service Engine Soon", "ECS" (Engine Control System), "Power Loss", and "PGMFI," while some vehicles have more than one of these fights.
- Some manufacturers illuminate the check engine light anytime any type of code is set, others light it only when specific emission-related codes are set.

Non-emission related codes are not always differentiated from emission-related codes. Codes for the cruise control, air conditioning, or anti-theft systems, may be intermixed with fuel/emission control system codes.

These variations in implementation between the manufacturers are not readily tolerated by our I/M inspection methods, methods that rely more on regimented procedures and across-the-board standards. Therefore, because of their inconsistencies, the use of the check engine light, or the presence of OBD codes, were essentially written off as official pass/fail inspection tools. When used as a service tool however, OBD has been tremendously successful in aiding repair technicians in diagnosing and repairing fuel management computer malfunctions. The technology in today's microprocessor based tools has sorted out the variations and inconsistencies between the OBD systems, essentially making most of the differences virtually transparent to the technician. This has allowed technicians to take full advantage of the self diagnostic capabilities of the fuel/emission computers. Not using these capabilities would be equivalent to a doctor not asking his patient what additional symptoms are accompanying a high fever. The additional symptoms serve to narrow the possible causes. The doctor doesn't just treat the fever, he treats its causes. Neglecting to use the insight provided by the OBD system, will certainly waste many emission repair dollars.

Not only are today's engine control systems more complex and varied than ever before, they are getting smarter. This makes it increasingly more difficult for a mechanic to second guess what may be causing a particular vehicle symptom to occur. All the systems do not react the same. Each system contains its own unique, built-in alternative strategies for possible failures. The first generation computers, upon detecting a problem, set a code, but continued to use values from the suspicious sensor. Succeeding generations started substituting nominal values, or values from other sensors measuring similar parameters. Today, Ford touts their FEMS or Failure Effects Management System. This system, for example, when detecting an excessively rich running condition, will divert air from being injected into the catalytic converter, thus keeping the converter from performing its intended function. Here, the purpose is to keep the converter from burning up prematurely, before the cause of the problem can be detected and corrected. An emission repair mechanic, however, charged with lowering emission levels, who doesn't customarily pull codes from the computer, might not know that air was intentionally being diverted from the converter. He might solve the emissions problem by hot wiring the air divert solenoid ON. This would serve to lower the emissions levels to pass the test, but defeat the purpose of the emission control system, leading to a more expensive repair down the road. Until the vehicle fails its next biennial inspection, it's a gross polluter. At its next inspection, the vehicle owner would only to need replace the converter. It costs more than $450-and would not be required to fix the original problem.

In conclusion, the best technicians wouldn't think of addressing an emission failure, or a driveability problem for that matter, without first determining if the computer has itself detected a problem. These fault codes are essential to effective diagnosis and repair. While the non-standard OBD might have disappointed a few in the inspection arena, it's utility and necessity should not be overlooked by those involved on the field of I/M repair.

WHY DO VEHICLES HAVE OBD ?

I DEFINITIONS

- ON-BOARD DIAGNOSTIC
- OBD AND OBD I
- OBD II

II. THE "I" INSPECTION SIDE OF OBD

WHY OBD IN THE INSPECTION PROCESS

WHEN OBD WILL BE PERFORMED

TEST RESULTS

III. "M" MAINTENANCE SIDE OF OBD

WHY OBD IN THE INSPECTION PROCESS

WHEN OBD WILL BE PERFORMED

THE CHALLENGE THAT EXISTS TO UTILIZE OBD IN THE INSPECTION PROCESS

WHY DO VEHICLES HAVE OBD?

ON-BOARD DIAGNOSTICS WERE FIRST USED BY THE MANUFACTURERS ENGINEERS TO CHECK THE COMPUTER SYSTEMS THEY WERE DESIGNING

THE CALIFORNIA AIR RESOURSES BOARD (CARB) SET MINIMUM STANDARDS, REQUIRING OBD ON VEHICLES SOLD IN CALIFORNIA.

FEDERAL EPA SET FEDERAL STANDARDS FOR THE USE OF ON-BOARD DIAGNOSTICS FOR VEHICLE MANUFACTURERS.

THE PURPOSE OF OBD

INCREASED CUSTOMER SATISFACTION

LOWER EMISSIONS

SYSTEM PROTECTION

SELF CAMPAIGNING

IMPROVED SERVICE

ASSEMBLY PLANT TESTS

THE DEFINITION OF ON-BOARD DIAGNOSTICS

THE INTERROGATION OF ENGINE CONTROL SYSTEMS IS PERFORMED BY THE ON-BOARD COMPUTER WHILE THE VEHICLE IS BEING DRIVEN.

THE COMPLETE DIAGNOSTIC SYSTEM ENCOMPASSES THE HARDWARE AND SOFTWARE IN THE CONTROLLER THAT PERFORMS FIVE (5) KEY FUNCTIONS.

FUNCTIONAL MONITORING
FAULT INDICATION OR WARNING
FAULT STORAGE
DEFAULT SUBSTITUTION
COMMUNICATION LINK

THE DEFINITION OF OFF-BOARD DIAGNOSTICS

OFF-BOARD DIAGNOSTIC SYSTEMS REQUIRE AN EXTERNAL DEVICE TO MONITOR THE VEHICLE ELECTRONIC SYSTEMS AND WATCH FOR SUSPECTED PROBLEMS WHILE THE VEHICLE IS BEING OPERATED.

OFF-BOARD DISGNOSTIC EQUIPMENT CONNECT TO THE VEHICLE'S ON-BOARD DIAGNOSTIC SYSTEM BY WAY OF THE DIAGNOSTIC CONNECTOR

ON-BOARD DIAGNOSTICS

FUNCTIONAL MONITORING

THAT IS THE TRACKING OF THE SYSTEM INPUTS TO VERIFY PROPER SENSOR OPERATION AND INFORMATION CONCERNING THE MONITORING OF THE OUTPUTS AND OVERALL SYSTEM OPERATION IN ORDER TO VERIFY PROPER CONTROLLER OUTPUT OPERATION.

FAULT INDICATION OR WARNING

IT MUST BE ABLE TO CAUSE THE ILLUMINATION OF THE MALFUNCTION INDICATOR LIGHT (MIL) WHEN A FAULT IS DETECTED.

TO MAINTAIN THE MIL ON FOR THE APPROPRIATE AMOUNT OF TIME AFTER THE FAULT IS DETECTED AND TO TURN OFF THE LIGHT WHEN THE FAULT IS NO LONGER PRESENT-

FAULT STORAGE

THE DIAGNOSTIC SYSTEM HAS THE ABILITY TO ASSIGN A "FAULT CODE" TO THE PARTICULAR FAULT DETECTED AND STORE THIS CODE UNTIL A SERVICE TECHNICIAN CAN ATTEND TO THE VEHICLE.

DEFAULT SUBSTITUTION

THE ABILITY TO SUBSTITUTE DEFAULT PARAMETERS WHEREVER APPROPRIATE WHEN A FAULT IS DETECTED OR TO PROVIDE BACK-UP CONTROL *OF* A SYSTEM, IF DEEMED NECESSARY-

COMMUNICATION LINK

PROVIDE THE ABILITY TO COMMUNICATE DIAGNOSTIC INFORMATION TO OFF-BOARD SYSTEMS WHEN REQUIRED.

OBD AND OBDI

VERY SOPHISTICATED SYSTEMS WERE NEEDED ACCURATELY CONTROL ALL OF THE ENGINE OPERATING PARAMETERS THAT EFFECT EMISSIONS.

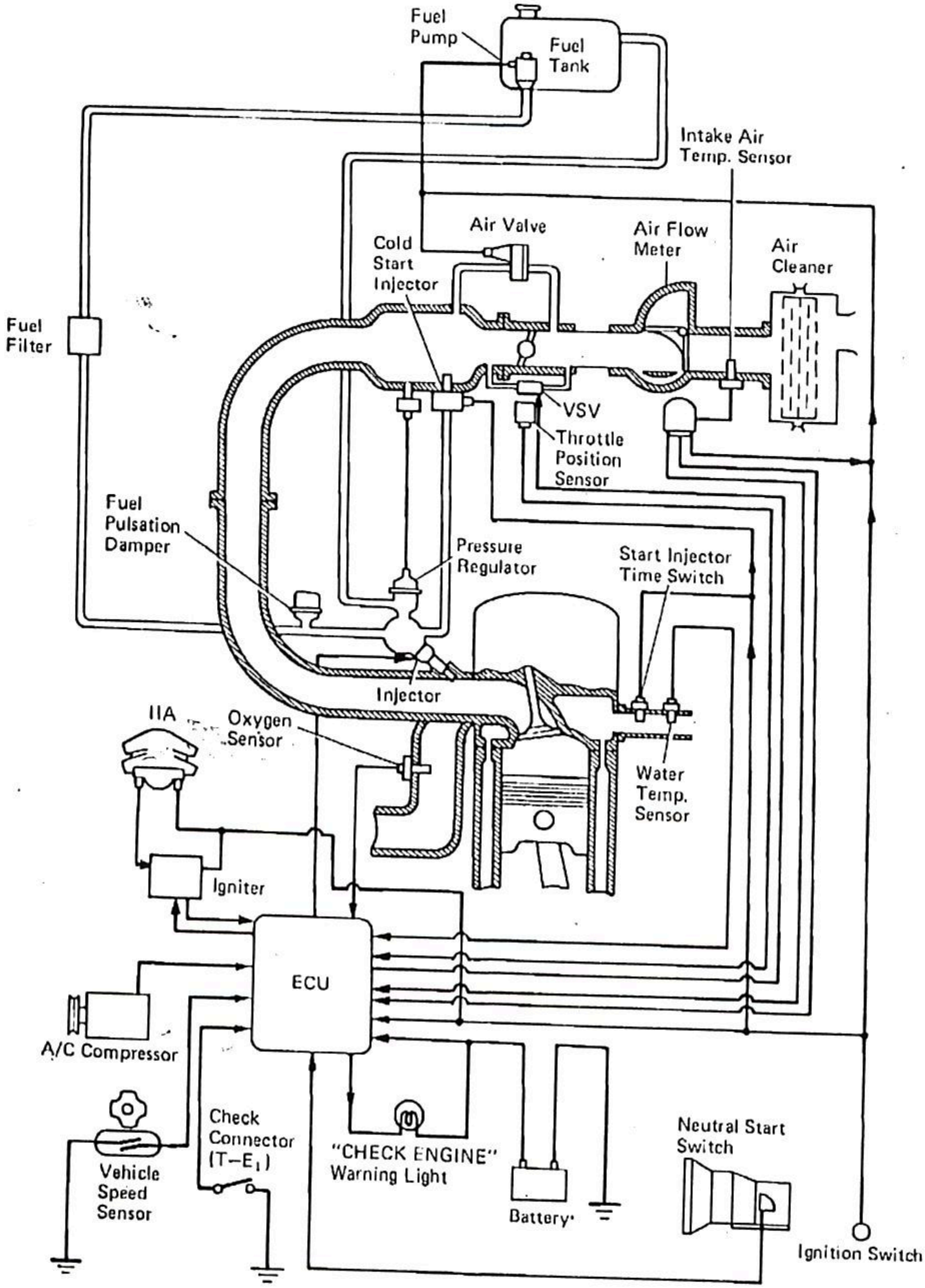
OBJECTIVE

- STORE TROUBLE CODES
- ILLUMINATE "CHECK ENGINE" LIGHT
- MONITOR SENSOR INPUT LIMITS FOR PROPER OPERATION -
- MONITOR SELECT OUTPUTS FOR LIMITS FOR PROPER OPERATION
- OBD AND OBD-I HAD A ESTIMATED AVERAGE OF 10 TO 20 FAULT CODES TO HELP TECHNICIANS DIAGNOSIS EMISSION/ENGINE MANAGEMENT PROBLEMS IN ORDER TO PERFECT REPAIR TECHNIQUES ON THE AFFECTED VEHICLES-

EXAMPLE

1981 GM 2.OL 4 CYLINDER ENGINE FAULT CODES

12 NO REFERENCE PULSES
13 OXYGEN SENSOR
14 COOLANT TEMPERATURE INPUT HIGH
15 COOLANT TEMPERATURE INPUT LOW
21 THROTTLE POSITION INPUT HIGH
23 CARBURETOR SOLINOID LOW
24 VEHICLE SPEED SENSOR
32 BAROMETRIC PRESSURE INPUT LOW
34 PRESSURE SENSOR INPUT ERROR
35 THROTTLE SWITCH ERROR
41 NO REFERENCE PULSES WHILE RUNNING
42 IGNITION MODULE ERROR
43 ESC RETARD SIGNAL ERROR
44 LEAN OXYGEN SENSOR
51 PROM ERROR
52 ECM MEMORY ERROR
54 CARBURETOR SOLENOID DRIVER ERROR



System Diagram

Computers and Control Systems: Electrical Diagrams
System Diagram

ON-BOARD

DIAGNOSTICS

GENERATION II

(OBD II)

COMPREHENSIVE COMPONENT MONITORING

A. INPUT COMPONENTS

THE DIAGNOSTIC SYSTEM SHALL MONITOR FOR MALFUNCTION ANY ELECTRONIC POWERTRAIN COMPONENT/SYSTEM WHICH CAN EFFECT EMISSIONS NOT OTHER-WISE DESCRIBED.

B. OUTPUT COMPONENTS

THE DIAGNOSTIC SYSTEM SHALL MONITOR FOR PROPER FUNCTIONAL RESPONSE OF ANY POWERTRAIN OUTPUT COMPONENT/SYSTEM WHICH CAN EFFECT EMISSIONS.

C. COMPONENTS/SYSTEM

SHALL BE MONITORED CONTINUOUSLY

TAMPERING PROTECTION

COMPUTER-CODED ENGINE OPERATING PARAMETERS SHALL NOT BE CHANGEABLE WITHOUT THE USE OF SPECIALIZED TOOLS AND PROCEDURES. ANY REPROGRAMMABLE COMPUTER CODE SYSTEM (E.G.EEPROM) SHALL INCLUDE PROVEN WRITE-PROTECT FEATURES...

READINESS/FUNCTION CODE

IF A FULL DIAGNOSTIC CHECK OF ALL MONITORED COMPONENTS AND SYSTEMS HAS NOT BEEN COMPLETED SINCE THE COMPUTER MEMORY WAS LAST CLEARED, A CODE SHALL STORE INDICATING THE NEED FOR ADDITIONAL MIXED CITY AND HIGHWAY DRIVING TO COMPLETE THE CHECK. THE DIAGNOSTIC SYSTEM SHALL ALSO INCLUDE A CODE OR ACKNOWLEDGE MESSAGE INDICATING THAT THE DIAGNOSTIC SYSTEM ITSELF IS FUNCTIONING PROPERLY.

EXHAUST GAS RECIRCULATION (EGR) SYSTEM MONITORING

A. THE DIAGNOSTIC SYSTEM SHALL MONITOR THE EGR SYSTEM ON VEHICLES SO EQUIPPED FOR LOW AND HIGH FLOW RATE MALFUNCTIONS.

B. THE EGR SYSTEM WILL BE CONSIDERED MALFUNCTIONING WHEN THE FLOW RATE CAUSES VEHICLE EMISSIONS TO EXCEED 1.5 TIMES ANY APPLICABLE FTP STANDARD.

OXYGEN SENSOR MONITORING

A. ALL OXYGEN SENSOR OUTPUT VOLTAGE, RESPONSE RATE AND ANY OTHER PARAMETER WHICH CAN AFFECT EMISSIONS WILL BE MONITORED FOR MALFUNCTION

B. AN OXYGEN SENSORWILL BE CONSIDERED MALFUNCTIONING WHEN THE VOLTAGE, RESPONSE RATE, OR OTHER CRITERIA ARE EXCEEDED AND CAUSES EMISSIONS TO EXCEED 1.5 TIMES ANY APPLICABLE FTP STANDARDS.

MISFIRE DETECTION

A. THE DIAGNOSTIC SYSTEM SHALL MONITOR ENGINE MISFIRE AND SHALL IDENTIFY SPECIFIC CYLINDER EXPERIENCING MISFIRE.

B. MONITORING CONDITIONS FOR 1997 AND LATER VEHICLES WILL BE CONTINUOUS AND UNDER ALL POSITIVE TORQUE ENGINE SPEEDS AND CONDITIONS.

C. FOR PRE-1997 VEHICLES,MISFIRE SHALL BE MONITORED CONTINUOUSLY DURING POSITIVE TORQUE CONDITIONS WITHIN THE RANGE OF ENGINE SPEED AND LOAD CONDITION COMBINATIONS ENCOUNTERED DURING AN FTP TEST.

CATALYST MONITORING

A. THE DIAGNOSTIC SYSTEM WILL MONITOR THE CATALYTIC CONVERTER(S) FOR PROPER PERFOMANCE.

THE CATALYST SHALL BE CONSIDERED MALFUNCTIONING WHEN TOTAL HYDROCARBON (HC) CONVERSION EFFICIENCY FALLS BETWEEN 50 TO 60 %.

B. A CATALYST MONITORING CHECK SHALL OCCUR AT LEAST ONCE PER TRIP.

C. MONITORING OF THE HEATED CATALST SYSTEM IS THE SAME.

SECONDARY AIR SYSTEM MONITORING

A. ANY VEHICLE EQUIPPED WITH ANY FORM OF SECONDARY AIR DELIVERY SYSTEM SHALL HAVE THE DIAGNOSTIC SYSTEM MONITOR THE PROPER FUNCTIONING OF THE SECONDARY AIR DELIVERY SYSTEM AND ANY AIR SWITCHING VALVE.

UEL SYSTEM MONITORING

A. THE DIAGNOSTIC SYSTEM SHALL MONITOR THE FUEL DELIVERY SYSTEM SUCH THAT A VEHICLE'S EMISSIONS WOULD NOT EXCEED 1.5 TIMES ANY OF THE APPLICABLE FTP STANDARDS BEFORE A FAULT IS DETECTED.

B. THIS MONITORING SHALL OCCUR CONTINUOUSLY. THE MIL SHALL BE ILLUMINATED AND A FAULT CODE STORED NO LATER THAN THE END OF THE NEXT DRIVING CYCLE IN WHICH THE CRITERIA AND INTERVAL ARE AGAIN EXCEEDED.

AIR CONDITIONING SYSTEM REFRIGERANT MONITORING

A. THE DIAGNOSTIC SYSTEM SHALL MONITOR AIR CONDITIONING SYSTEMS FOR LOSS OF REFRIGERANTS WHICH COULD HARM THE STRATOSPHERIC OZONE LAYER OR ARE REACTIVE IN FORMING ATMOSPHERIC OZONE.

B. THE DIAGNOSTIC SYSTEM SHALL MONITOR THE AIR CONDITIONING SYSTEM AT LEAST ONCE PER TRIP.

EVAPORATIVE SYSTEM MONITORING

A. THE DIAGNOSTIC SYSTEM SHALL VERIFY AIR FLOW FROM THE COMPLETE EVAPORATIVE SYSTEM.

B. AN EVAPORATIVE SYSTEM SHALL BE CONSIDERED MALFUNCTIONING WHEN NO AIR FLOW FROM THE SYSTEM CAN BE DETECTED,OR WHEN A SYSTEM LEAK IS DETECTED.

OBD-II

DTC Format

Diagnostic Trouble Codes for EEC-V are formatted according to SAE J2012. SAE J2012 dictates a five-digit alphanumeric DTC with each digit defined as follows:

- Prefix letter of DTC indicates DTC function:
  - P — Powertrain
  - B — Body
  - C — Chassis
- First number indicates who was responsible for DTC definition:
  - 0 — SAE
  - 1 — Manufacturer
- Third digit of powertrain DTC indicates subgroup:
  - 0 — Total System
  - 1 — Fuel/Air Control
  - 2 — Fuel/Air Control
  - 3 — Ignition System/Misfire
  - 4 — Auxiliary Emission Controls
  - 5 — Idle/Speed Control
  - 6 — PCM and I/O
  - 7 — Transmission
  - 8 — Non-EEC Powertrain
- The fourth and fifth digit specify the area involved.

Let's take a possible DTC and break it into defined segments.

For Example: P1711

- P — First digit letter indicates a Powertrain DTC.
- 1 — Second digit indicates a manufacturer defined DTC.
- 7 — Third digit indicates a transmission sub-group concern.
- 11 — Fourth and fifth digits indicate a TOT Circuit out of range.

DTC	Circuit Or Condition
P1133	HO2S/O2S Insufficient Switching Sensor 1
P1134	HO2S Transition Time Ratio Sensor 1
P1139	HO2S Insufficient Switching Bank 1 Sensor 2
P1140	HO2S Transition Time Ratio Bank 1 Sensor 2
P1153	HO2S Insufficient Switching Bank 2 Sensor 1
P1154	HO2S Transition Time Ratio Bank 2 Sensor 1
P1171	Fuel System Lean During Acceleration
P1187	EOT Sensor Circuit Low Voltage
P1188	EOT Sensor Circuit High Voltage
P1200	Injector Control Circuit
P1214	Injection Pump Timing Offset
P1216	Fuel. Solenoid Response Time Too Short
P1217	Fuel. Solenoid Response Time Too Long
P1218	Injection Pump Calibration Circuit
P1222	Injector Control Circuit Intermittent
P1250	Early Fuel Evaporative Heater Circuit
P1257	Supercharger System Overboost
P1258	Engine Metal Over Temperature Protection
P1275	Boost Control Problem
P1300	Ignition Control Module Circuit
P1320	ICM 4X Reference Circuit Too Many Pulses
P1323	ICM 24X Reference Circuit Low Frequency
P1345	CKP Sensor/CMP Correlation
P1350	Ignition Control System
P1351	Ignition Control Circuit High Voltage
P1361	IC Circuit Not Toggling
P1361	Ignition Control Circuit Low Voltage (Distributor Ignition)
P1370	ICM 4X Reference Too Many Pulses
P1371	ICM 4X Reference Too Few Pulses
	Distributor Ignition Low Resolution Circuit
P1374	3X Reference Circuit
P1375	ICM 24X Reference Voltage Too High
P1376	Ignition Ground Circuit
P1377	ICM Cam Pulse To 4X Reference Pulse Comparison
P1380	Electronic Brake Control Module DTC Detected/Rough Road Data Unusable
P1381	Misfire Detected No EBCM/PCM Serial Data
P1403-P1405	EGR Error
P1406	EGR Valve Pintle Position Circuit
P1408	MAP Sensor Circuit
P1410	Fuel Tank Pressure System
P1415	AIR System Bank 1
P1416	AIR System Bank 2
P1441	EVAP System Flow During Non-Purge
P1442	EVAP Vacuum Switch Circuit
P1450	BARO Sensor Circuit
P1451	BARO Sensor Circuit
P1460	Cooling Fan Circuit
P1500	Starter Signal Circuit
P1508	IAC System Low RPM
P1509	IAC System High RPM
P1510	Backup Power Supply
P1520	Park/Neutral Position Switch Circuit
P1524	TPS Learned Closed Throttle Angle Degrees Out Of Range
P1526	TPS Learn Not Completed

Typical Codes
OBD-II

DTC	Circuit Or Condition
P1530	Ignition Timing Adjustment Switch Circuit 2
	A/C Refrigerant Pressure Sensor Error
P1532	A/C Evaporator Temperature Circuit Low Voltage
P1533	A/C Low Side Temperature Sensor Circuit
P1535	A/C High Side Temperature Sensor Circuit
P1536	A/C System ECT Over Temperature
P1537	A/C Request Circuit Voltage Low
P1538	A/C Request Circuit Voltage High
P1539	A/C High Pressure Switch Circuit High Voltage
P1540	A/C System High Pressure
P1542	A/C System High Pressure/High Temperature
P1543	A/C System Performance
P1545	A/C Clutch Relay Control Circuit
P1546	A/C Clutch Relay Control Circuit Low Voltage
P1550	Stepper Motor Cruise Control
P1554	Cruise Control Status Circuit
P1558	Cruise Control (SPS Low)
P1560	Cruise Control System/Transaxle Not In Drive
P1561	Cruise Control Vent Solenoid
P1562	Cruise Control Vacuum Solenoid
P1564	Cruise Control System/Vehicle Acceleration Too High
P1565	Cruise Control Servo Position Sensor
P1566	Cruise Control System/Engine RPM Too High
P1567	Cruise Control Switches
P1568	Cruise Control (SPS High)
P1570	Cruise Control System/Traction Control Active
P1571	TCS Desired Torque Circuit
	Traction Control System PWM Circuit No Frequency 3
P1572	Traction Control System Active Circuit Low Voltage Too Long
P1573	PCM/EBTCM Serial Data Circuit
	Engine Hot Lamp Control Circuit 4
P1574	EBTCM System/Stop Lamp Circuit High Voltage
P1575	Extended Travel Brake Switch Circuit High Voltage
P1576	Brake Booster Vacuum Sensor Circuit High Voltage
P1577	Brake Booster Vacuum Sensor Circuit Low Voltage
P1578	Brake Booster Vacuum Sensor Circuit Low Vacuum
P1579	Park/Neutral To Drive/Reverse At High Throttle Angle
P1599	Engine Stall Or Near Stall Detected
	Cruise Control Management 5
P1600	PCM Battery
	Serial Communication Between PCM & TCM
P1601	Loss Of Serial Communication
P1602	Loss Of EBTCM Serial Data
P1603	Loss Of SDM Serial Data
P1604	Loss Of IPC Serial Data
P1605	Loss Of HVAC Serial Data
P1610	Loss Of PZM Serial Data
P1611	Loss Of CVRTD Serial Data
P1619	Engine Oil Life Monitor Reset Circuit
P1621	PCM Memory Performance
P1623	PROM Error
P1626	Theft Deterrent System Fuel Enable Circuit
P1627	A/D Performance
P1629	Theft Deterrent System Fuel Enable Circuit Incorrect Signal Detected During Engine Cranking
P1630	Theft Deterrent System/PCM In Learn Mode 2
	System Voltage Error

Continued

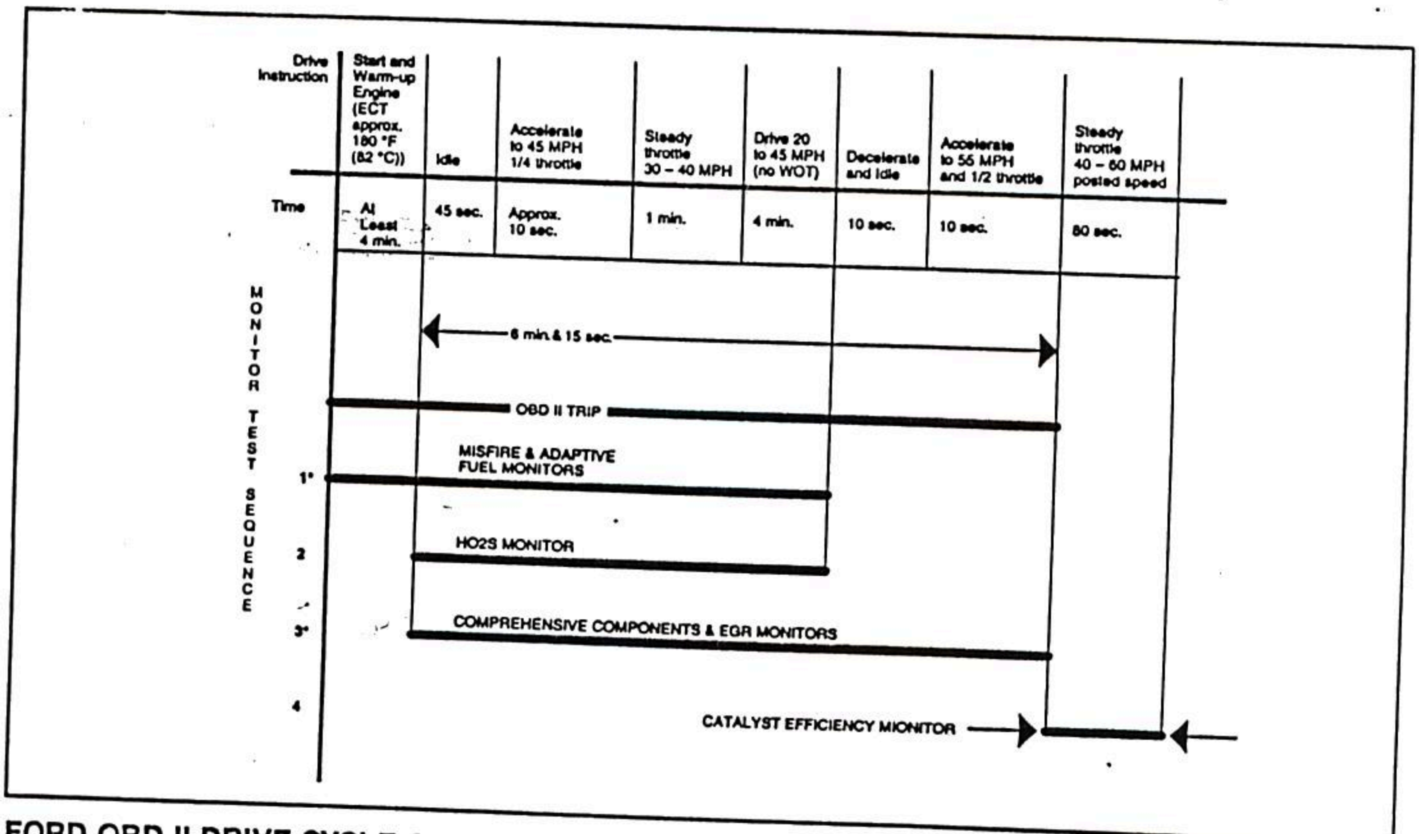
Ford OBD II Drive Cycle Definition

The Ford OBD II Drive Cycle is a specific driving pattern used to include all Trip Monitor tests plus the Catalyst Efficiency Monitor Test. Refer to Drive Cycles (Diagnostic Methods, PC/ED Section 2) for detailed instruction.

Ford OBD II Drive Cycle requirements include:

- All Trip monitors completed.
- The Catalyst Efficiency Monitor requires a steady drive mode (40 to 60 MPH) for a period of time beyond the completed HO2S Monitor test. The Catalyst Efficiency Monitor test must be completed after the Trip requirement of the Drive Cycle.

The following chart shows the Ford OBD II Drive Cycle.



FORD OBD II DRIVE CYCLE CHART

INFORMATION HIGHLIGHTS

- **An OBD II Drive Cycle is required to allow all EEC-V tests and monitors to function.**

REMOTE SENSING

APPLICATIONS

The Remote Smog Detector (RSD-1000) is being commercialized to complement and enhance State emission testing programs.

Potential applications include:

Random Inspection

The unit monitors vehicles and identifies gross emitters of CO or HC. The high emission readings are retained on VCR or computer disks with the photo of the vehicle, its license number, CO value, HC value, time and date.

Tamper Inspection

Vehicles with high levels of HC or CO may be selected to be pulled over for on-road tamper inspection by law enforcement agents.

Mass Data Collection

With the ability to monitor and capture data on up to 1000 vehicles per hour the RSD-1000 is ideally suited for gathering fleet data for analysis purposes e.g., age of vehicles, types of vehicles, geographic source of vehicles, emissions levels versus various parameters such as time, temperature, etc.

Hot Spot Inspection

Vehicles in "Hot Spot" areas can be monitored to identify gross emitters.

Attainment Monitoring

Once an area has achieved the air quality objective, the RSD-1000 can be used to gather mass fleet data. These data can be compared to future or past data to identify trends or changes in vehicle emissions and air quality.

Traffic Signal Setting

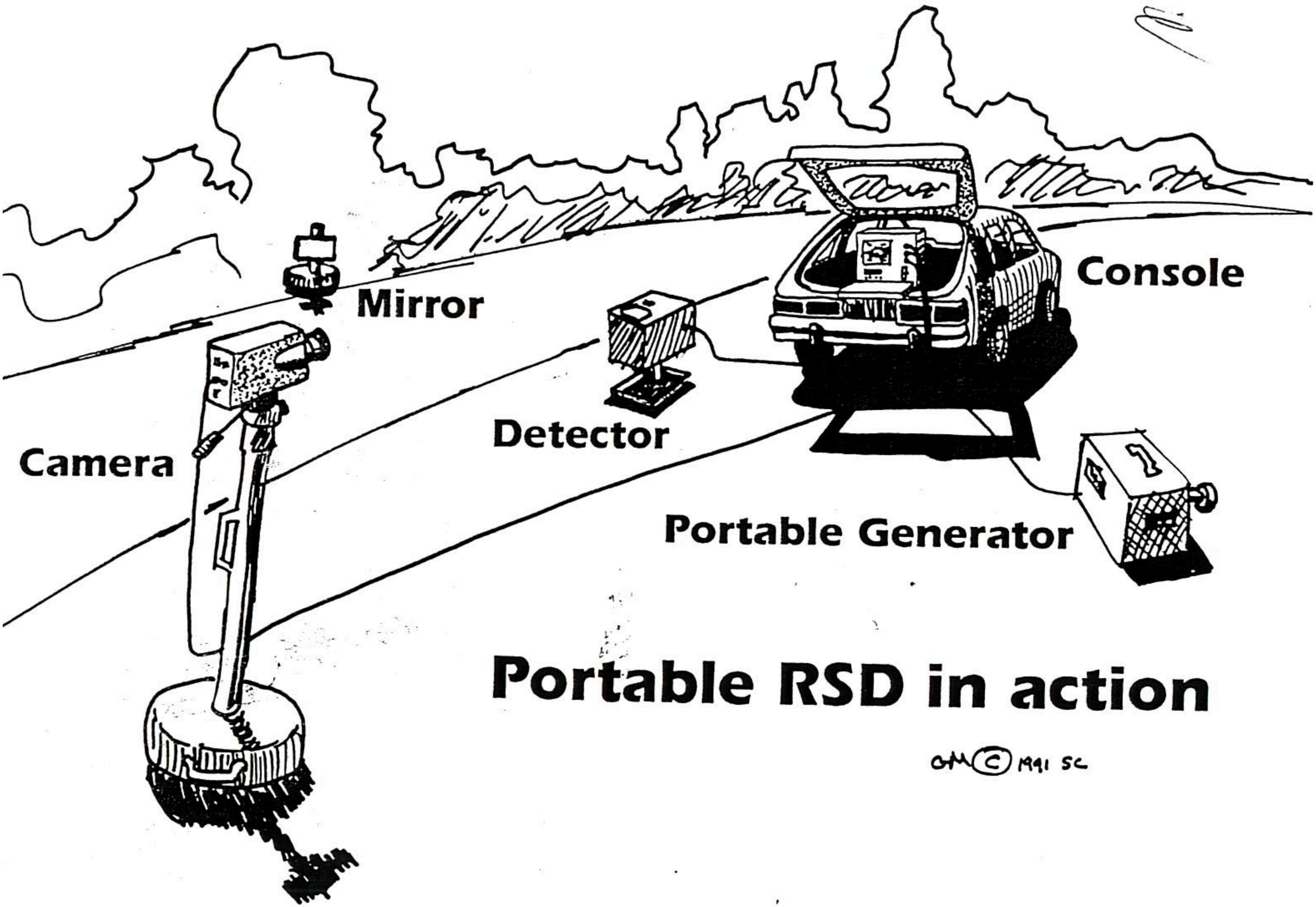
Traffic signal timing and throughway on-ramp gates can use data from a RSD-1000 to optimize the switching frequency to minimize emissions concentration.

Entrance/Access Limitation

Vehicles with gross emissions levels could be prohibited from entering tunnels or sensitive areas.

Driver Information

Emission levels could be monitored on the highway and displayed on lighted panels as acceptable or high. This would alert the driver to potential vehicle problems that may be contributing to poor fuel economy and high emissions.



Portable RSD in action

1 ecg ks

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL VEHICLE AND FUEL EMISSIONS LABORATORY
2565 PLYMOUTH ROAD
ANN ARBOR, MICHIGAN 48105

FEB 6 1996

RECEIVED
Air & Radiation Program
Branch (3AT10)

FEB 14 1996

EPA, REGION III

Mr. Michael Koerber, Technical Director
Lake Michigan Air Directors Consortium
2350 East Devon Avenue, Suite 242
Des Plaines, IL 60018

Dear Mr. Koerber:

This is in response to your letter of December 18, 1995, regarding the removal of national speed limit requirements and the implications of this change on highway mobile source emissions. Our recommendations for accounting for this change are summarized below.

As you are aware, the maximum input speed for the MOBILE5 emission factor model is 65 mph. The speed input for MOBILE5 is an average trip speed, and as such, an average speed of 65 mph includes operation at higher speeds. We recommend that vehicle miles traveled (VMT) that occurs at speeds over 65 mph be modeled as occurring at 65 mph. Thus, the effect of removing 65 mph speed limits is modeled by assuming that a greater fraction of VMT is accumulated at 65 mph than was true before the speed limit change. This is consistent with our traditional guidance that speeds over 65 mph be modeled at 65 mph in MOBILE5. We will be analyzing additional emission test data from higher speed cycles as it becomes available, but cannot provide a quantitative estimate of the emissions increase of higher travel speeds at this time.

For VMT occurring at or above 65 mph, and being modeled as 65 mph in MOBILE5, it is recommended that the operating mode be modeled as 100% hot stabilized (this corresponds to 0.0/0.0/0.0 as the operating mode inputs to MOBILE5). Vehicle start emissions (cold- or hot-start), should not be assumed in the modeling of emissions at these speeds.

The speed inputs and VMT fractions associated with various speeds should be based on field studies and traffic surveys, as is recommended in EPA's inventory preparation guidance. EPA does not have information on the real-world changes in traffic speed occurring as a result of speed limit increases above 65 mph, but this is the type of information that can and should be obtained through surveys performed by the relevant state transportation department or contractors hired to gather such data. Thus, our recommendation is that assumptions not supported by data <u>not</u> be used in estimating the extent (degree and frequency) of speed increases occurring after speed limits are increased in a given situation.

Finally, EPA has not yet determined what all of the impacts of this change will be with respect to the State Implementation Plan (SIP) and conformity processes. Additional guidance addressing these issues will be forthcoming.

If you wish to discuss this further, please feel free to contact us again.

Sincerely,

Philip A. Lorang, Director
Assessment and Modeling Division

cc: G. MacGregor, RSPD
D. Mobley, OAQPS-RTP
W. Schroeer, OPPE-DC
W. Becker, STAPPA
A. Marin, NESCAUM
A. Marner, FTA
J. Shrouds, FHWA
D. Schoeneberg, FHWA
Air Branch Chiefs, Reg. 1-10

Reinventing Transportation Policy:

Setting National Goals

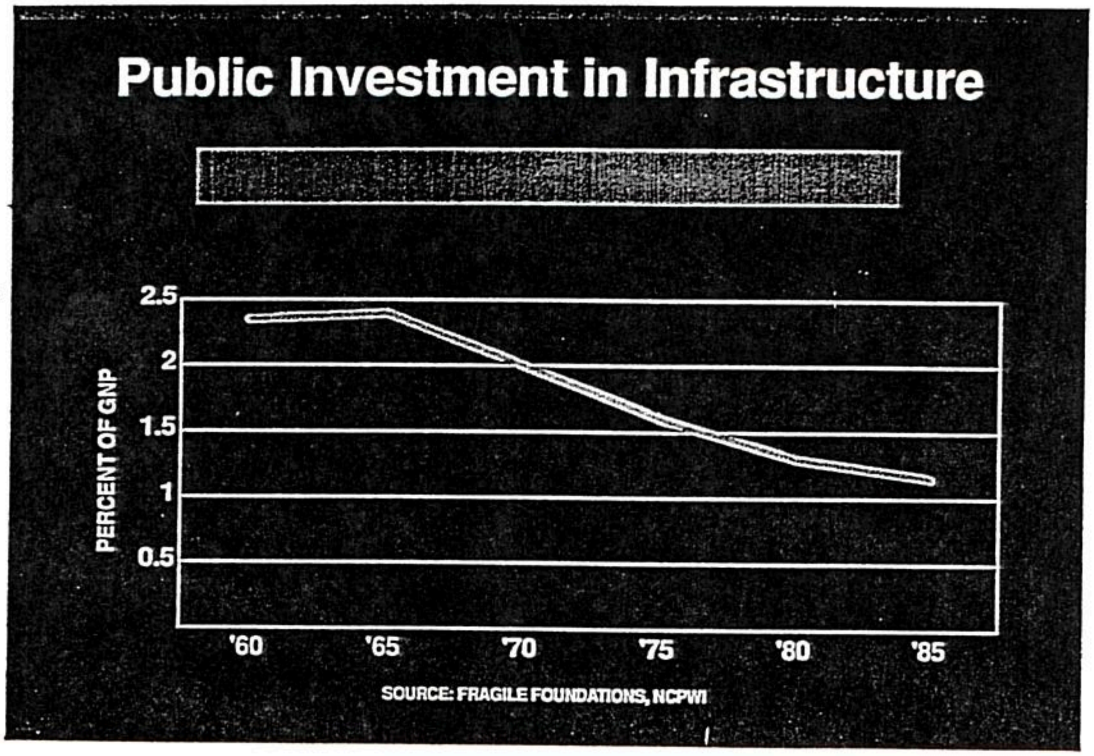
Louis J. Gambaccini, Chief Operations Officer/General Manager of the Southeastern Pennsylvania Transportation Authority has presented an earlier version of this slide presentation in a variety of forums around the country prior to this most recent revised format which was presented as the Candeub Lecture, Rutgers University, School of Planning and Public Policy, October 20, 1993.

Winston Churchill, 1941

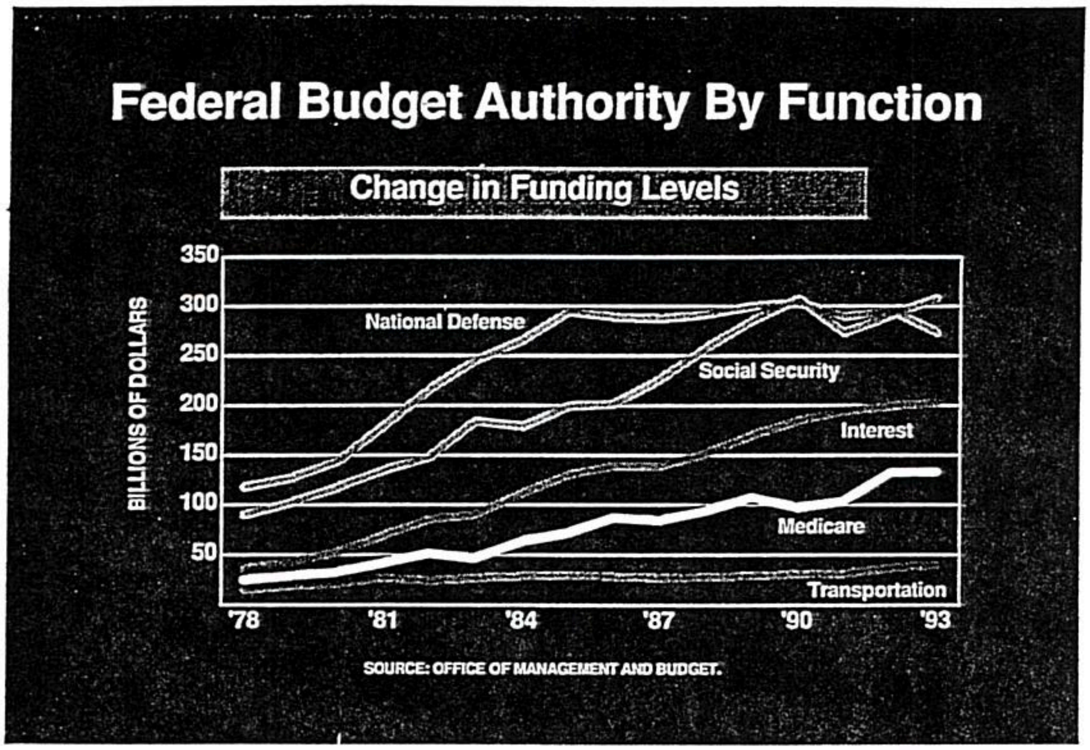
"You can count on the American people to do the right thing, after they've tried every other alternative."

To set the mood . . . Churchill is said to have made this statement just after America entered World War II.

In the wake of two landmark pieces of legislation--the Clean Air Act Amendments (CAAA) of 1990 and the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991--we have a golden opportunity to significantly change the direction of transportation policy. Unfortunately, we find that high statutory rhetoric and noble goals often fall prey to the day- to-day decision-making which is driven by political expediency and short term objectives and have the result of undermining lofty objectives.

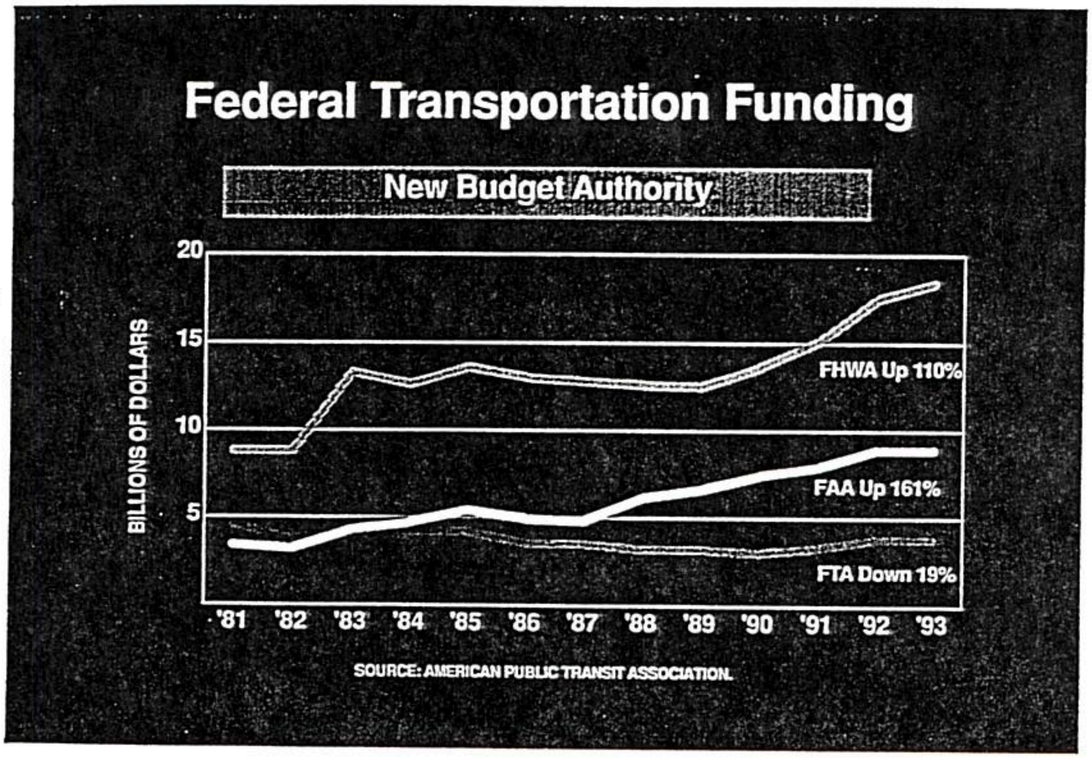


A study by a major commission on infrastructure shows the perilous course we have traveled as we continue to disinvest in infrastructure. As a percent of GNP, public investment in public capital, such as highways, sewer and water systems, and transit has fallen from a high in the mid-sixties of nearly 2.5 percent to 1985 levels around 1 percent. In a similar period, medical costs rose from 7% of GNP to more than 12% of GNP.



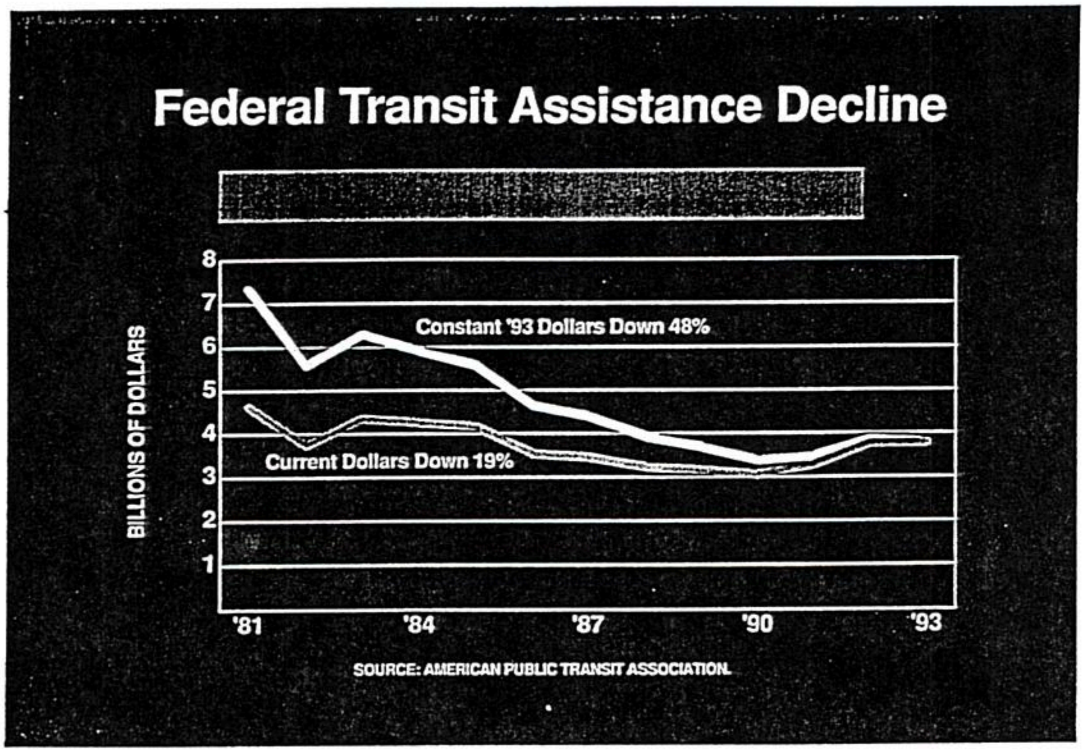
Over the last 15 years, within the federal budget, transportation funding has had a flat slope compared to other claimants for federal spending--such as national defense, social security, medicare and interest.

Unfortunately, our budgetary priorities have focused on <u>spending</u> rather than <u>investing</u> in our future.

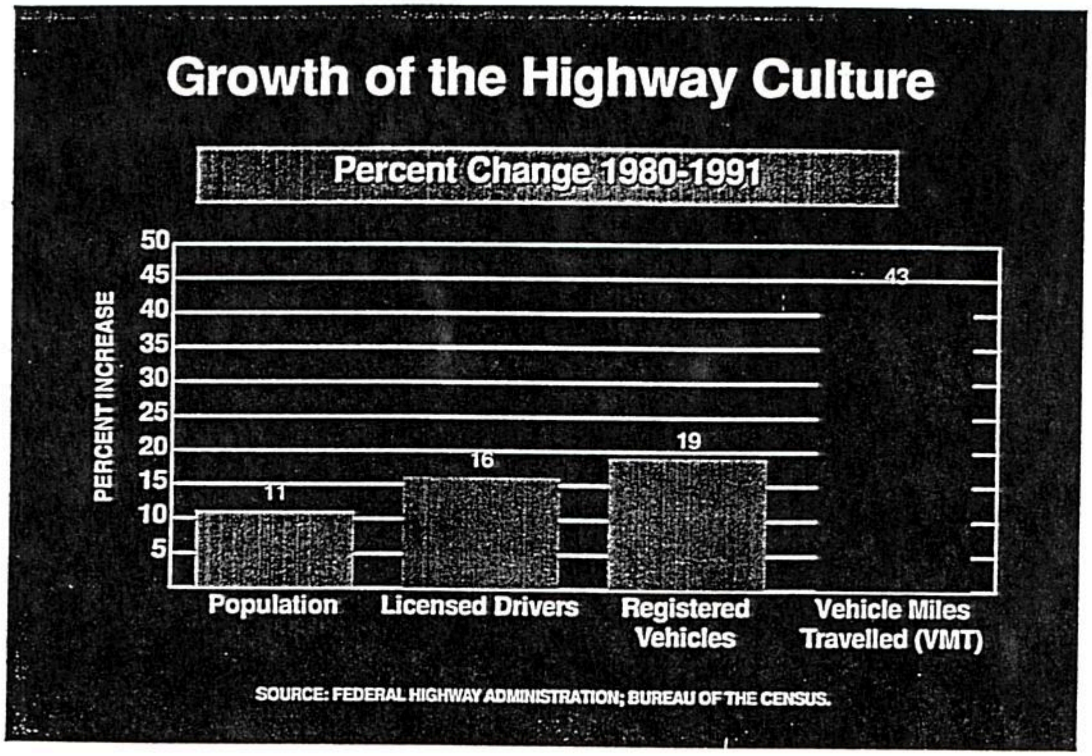


Within the flat slope of the transportation budget, federal spending on highways and aviation grew 110% and 161% respectively, while spending on transit dropped by 19%. While transportation as a percent of federal budget has been static since the 1980s, transit as a component of federal budget has been singled out for harsh treatment in comparison to other modes.

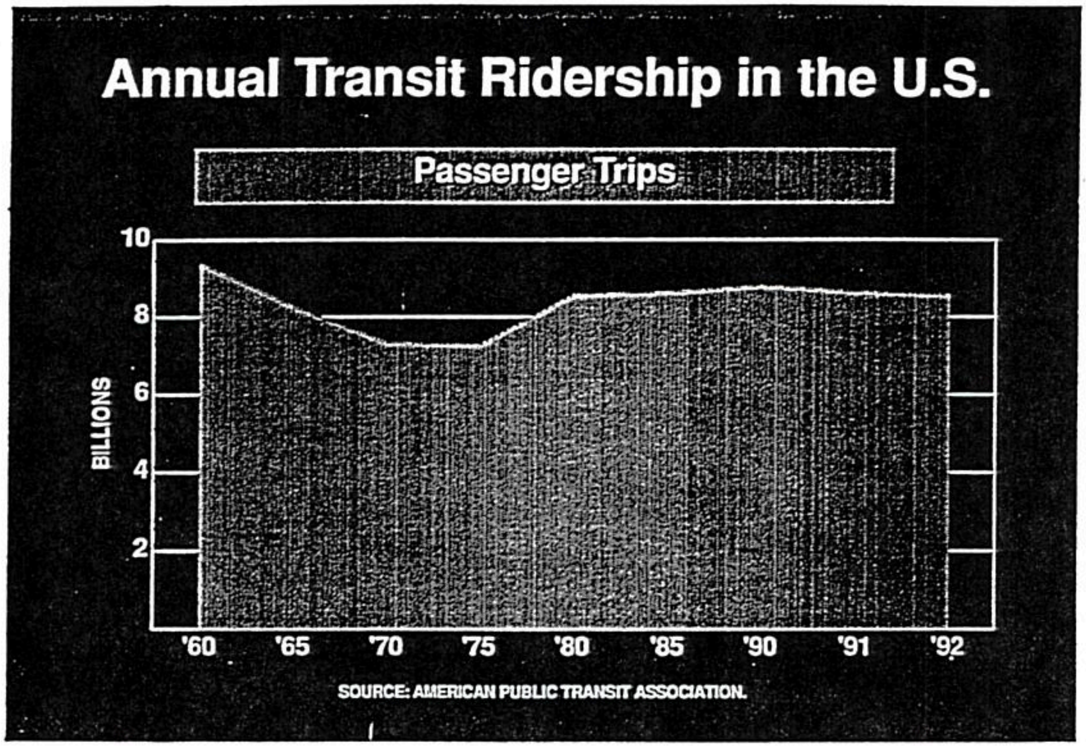
As a result, during the 1980s, people drove more and flew more, in part because the federal government increased its support of the highway and aviation systems. A similar commitment to public transportation would almost certainly have meant more transit service and more transit riders.



Federal transit assistance adjusted for inflation is down almost 50% in the last 12 years.

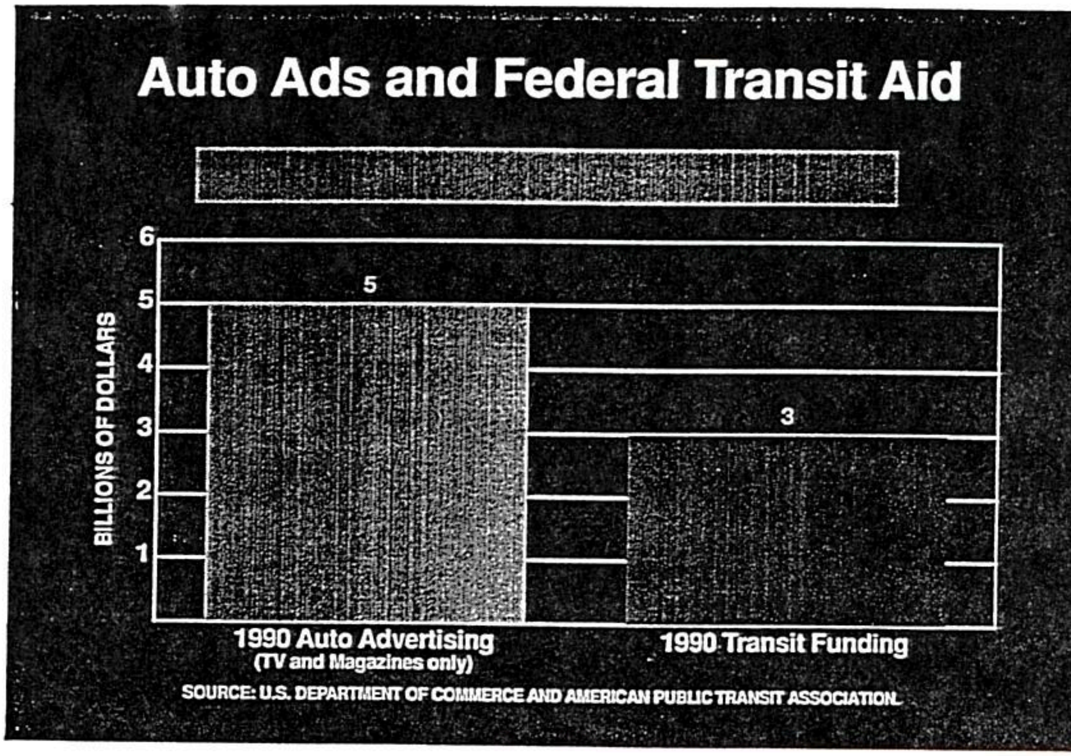


This is the most significant chart as it tells a deplorable story regarding transportation policy. Vehicle Miles Traveled (VMT) increased 43% in an 11 year period, far outpacing population growth which was only up 11%--this represents almost a four-fold rate of increase over population. Similarly, the growth in the number of licensed drivers and number of registered vehicles was far greater than population growth. These trends suggest a massive continuing demand for highways and single-occupant auto use. These trends have awesome implications which you will see in the charts to follow.



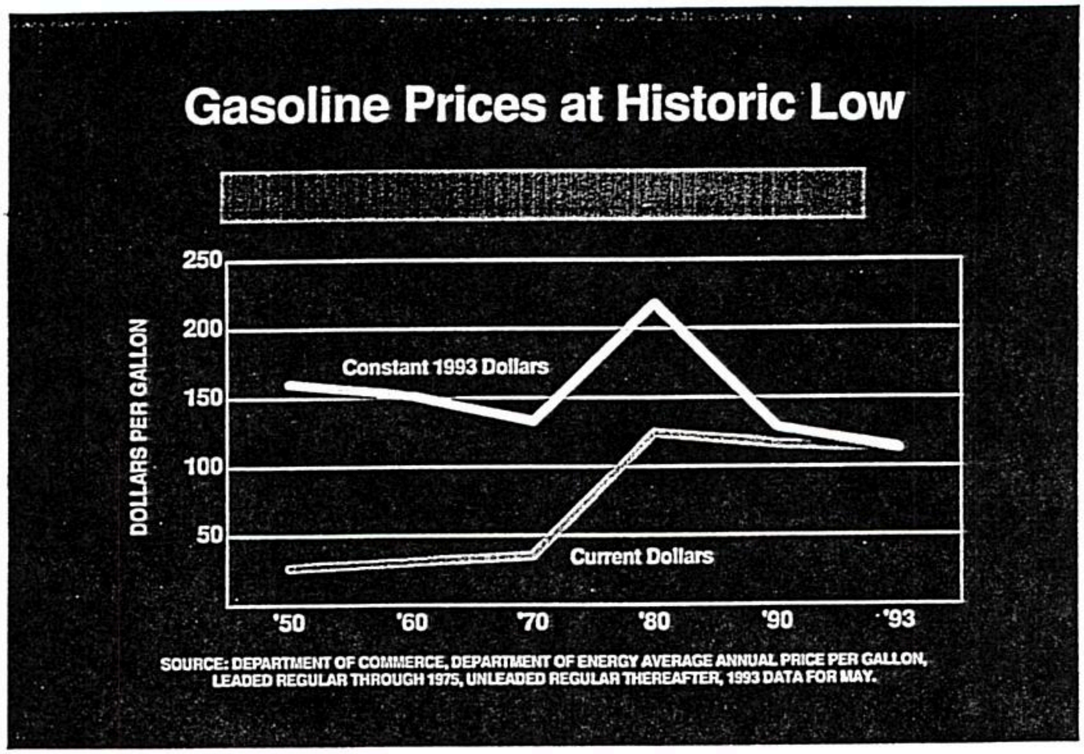
In the 1970s, we saw an end to what had been a precipitous decline in transit ridership since World War II--this change was largely attributable to the birth of the urban mass transit program. At that time, federal funding enabled transit systems across the country to prevent major service abandonments, aid public takeovers and facilitate the rehabilitation of transit infrastructure. Through its direct intervention, the federal government stabilized transit ridership.

Unfortunately, since the early 1980s our spending priorities and policies have accelerated support for the single-occupant auto and continued to drive up vehicle miles traveled (VMT). Despite these trends, it is quite remarkable that transit ridership has remained stable through the 80s and 90s.

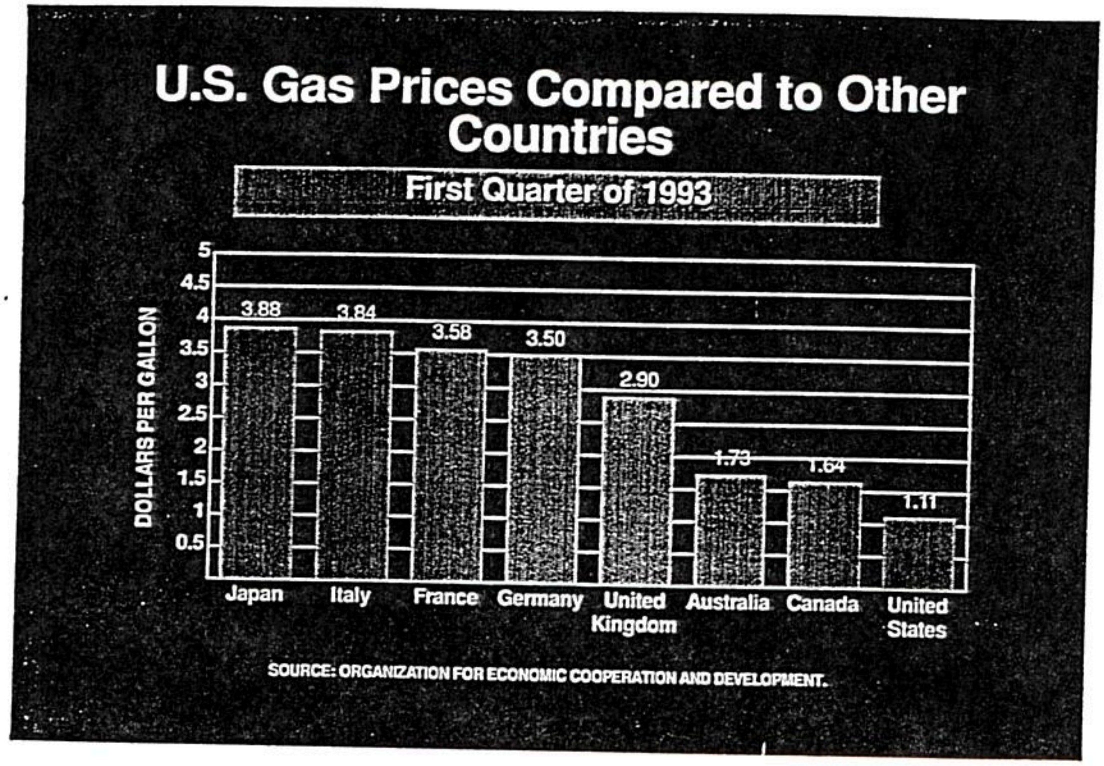


This chart depicts the disproportionate way in which funding flows in this country. Annually the amount of money spent on auto advertising for new cars far exceeds the budget for the entire federal transit program. Actually, the auto advertising figure is understated in that it only reflects TV and magazine advertising--no classified, used car or new car news print media costs are included in this figure. This advertising figure would be significantly higher if newspaper and radio advertising were included.

The automobile has taken up a critical place in our society. Indeed, our key indicators of a healthy economy are primarily auto related--new home starts and auto sales.

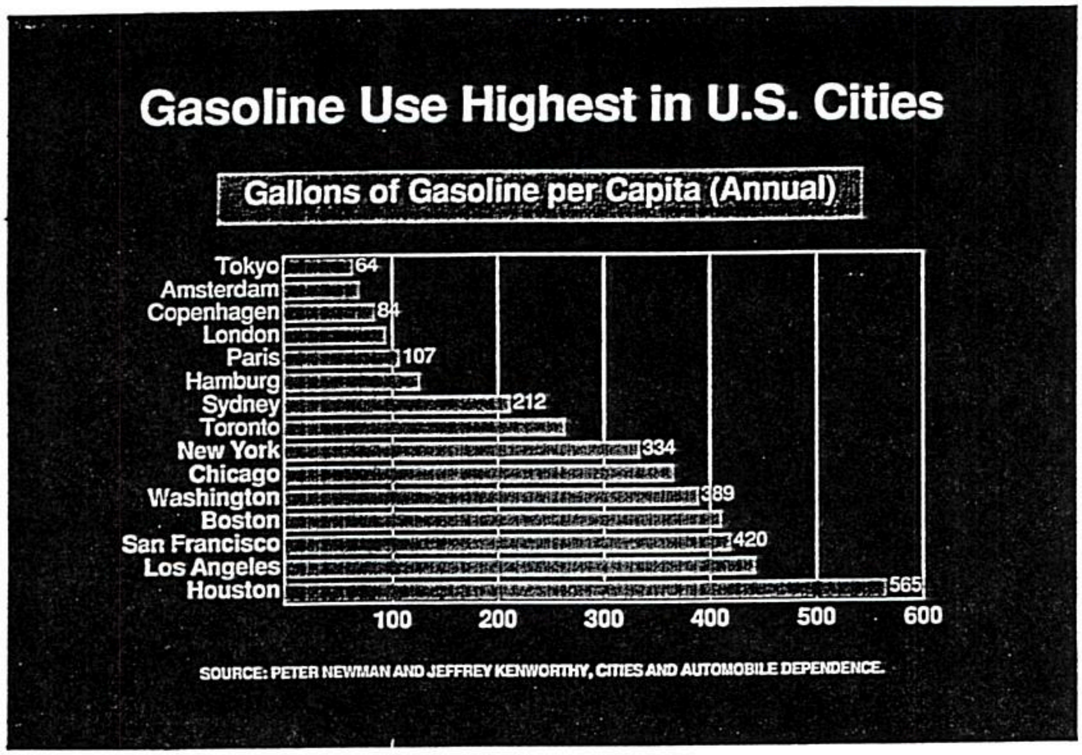


Gas prices, adjusted for inflation, are at the lowest point in the history of the automobile. Today, gas prices (adjusted for inflation) are actually below what they were 40 years ago. Artificially low gas prices have bolstered auto use in the U.S.

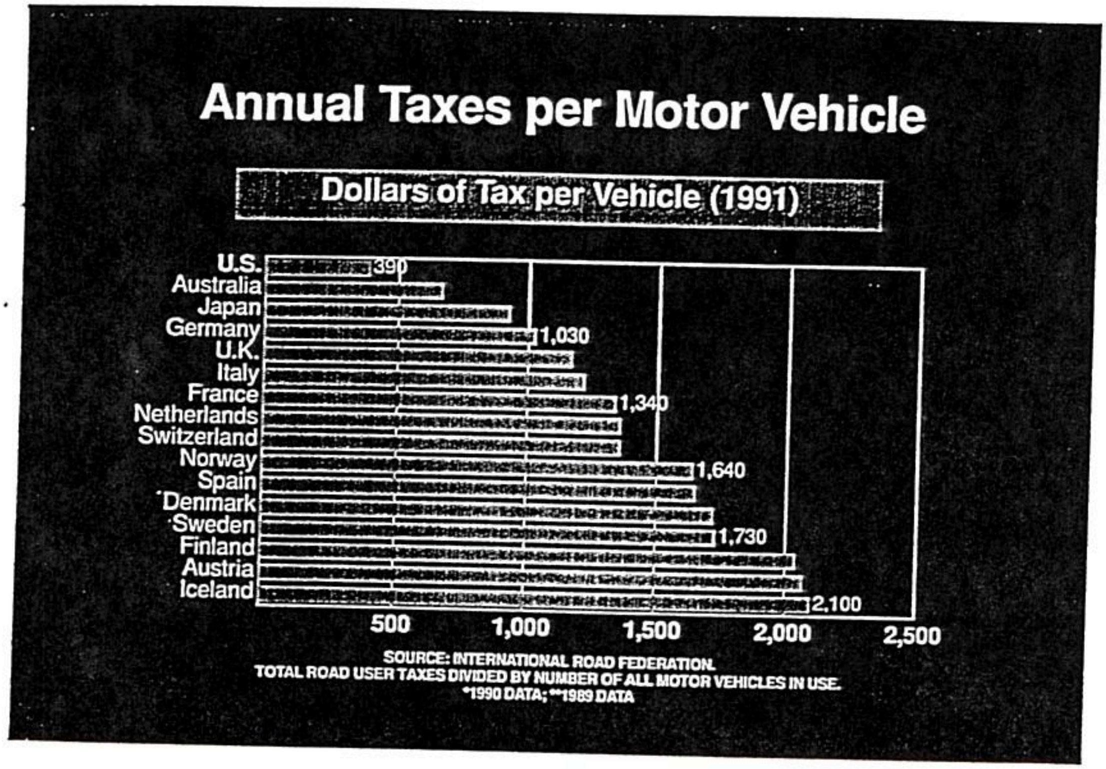


U.S. gas prices are fraction of what they are abroad. Gas prices in Europe are more than 3 times higher than they are in the U.S. For example, in France, Germany, Italy and Japan, gas prices are between $3.00 and $4.00 per gallon. In recent years, foreign gas prices have even run as high as $4.00 to $5.00.

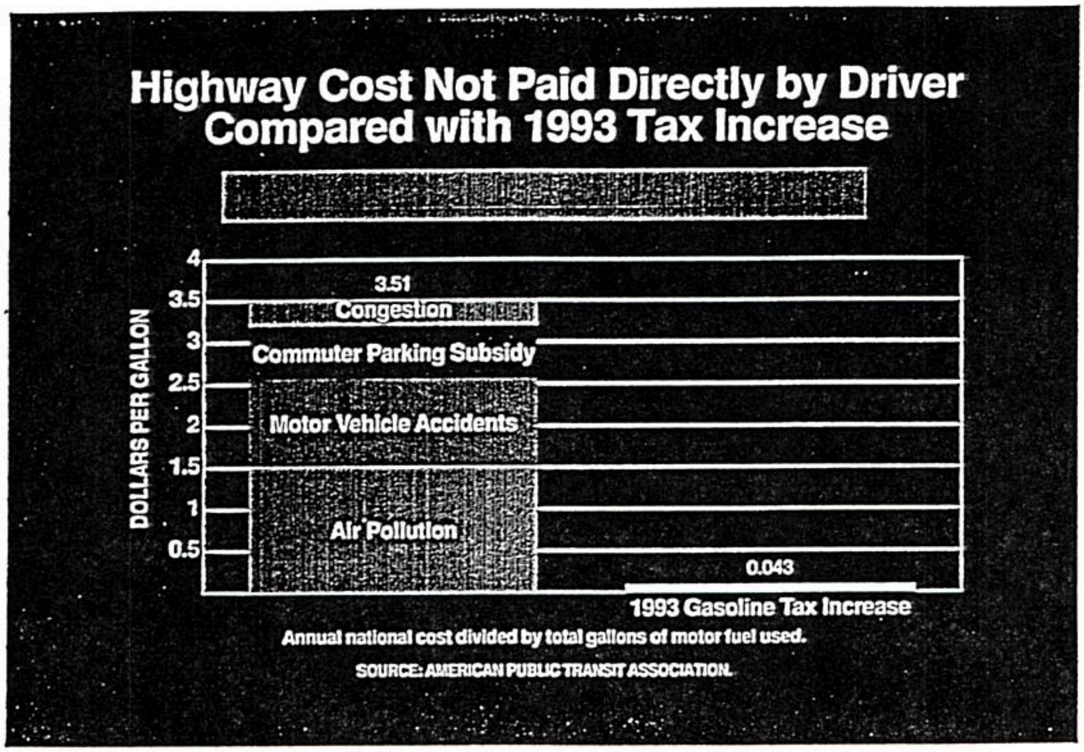
The main reason Americans pay so little for gas is because of our extraordinarily low gasoline tax. We pay, on average, 33 cents per gallon in taxes; whereas in Japan and Great Britain, people pay nearly $2.00 in taxes on each gallon of gasoline. In France, Germany and Italy, gas taxes total more than $2.50 per gallon. The revenue from those taxes pay for better transportation and other worthwhile government programs and discourage the profligate consumption of energy.



With the availability of cheap gas in the U.S., it should come as no surprise that there is a dramatic difference in per capita gasoline consumption in U.S. cities in comparison to European cities.

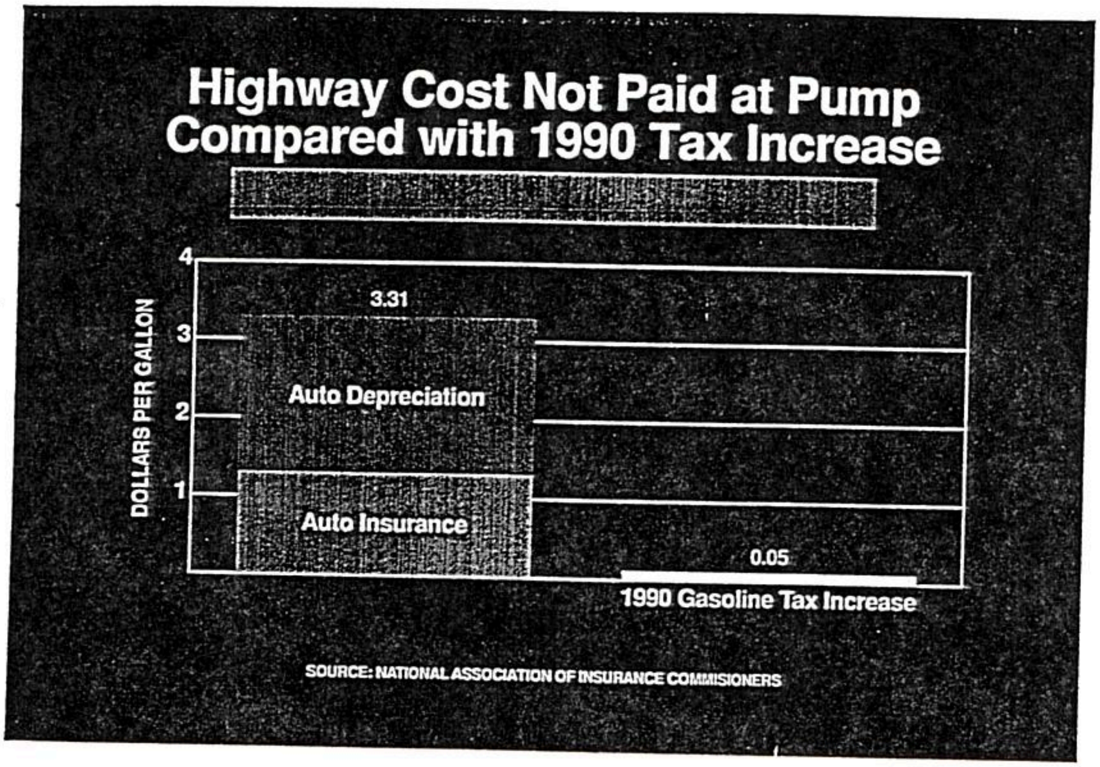


Taxes on motor vehicles in the U.S. are a fraction of what they are in other countries--$391 in the U.S. versus $1000-$2000 in most European countries. This disparity offers yet another incentive for Americans to purchase and use automobiles without having to make a fair contribution to pay for the cost associated with the automobile.



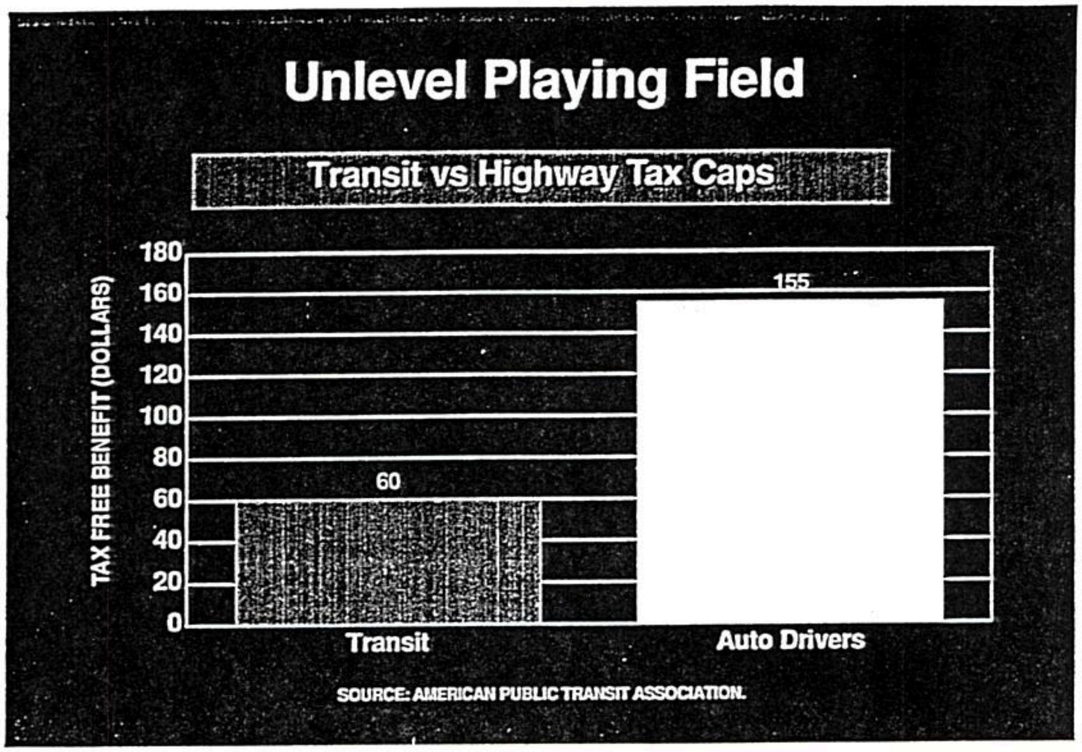
Few people realize that there are many hidden costs imposed by the automobile which are not paid by the driver. We see these costs in the form of congestion on the highways, commuter parking subsidies, motor vehicle accidents and air pollution which are all the result of auto use. These costs are buried and exist as hidden subsidies paid by taxpayers at large.

If these hidden costs were applied to average consumption of gas at the pump, they would equate to $3.51 ~~cents~~ per gallon. This is the additional amount every driver would have to pay to cover the cost of these societal problems. Within this context, if we consider the recent 4.3 cent tax, the tax increase looks rather trivial. However, we nearly had a political revolution in protest of the 4.3 cent tax.

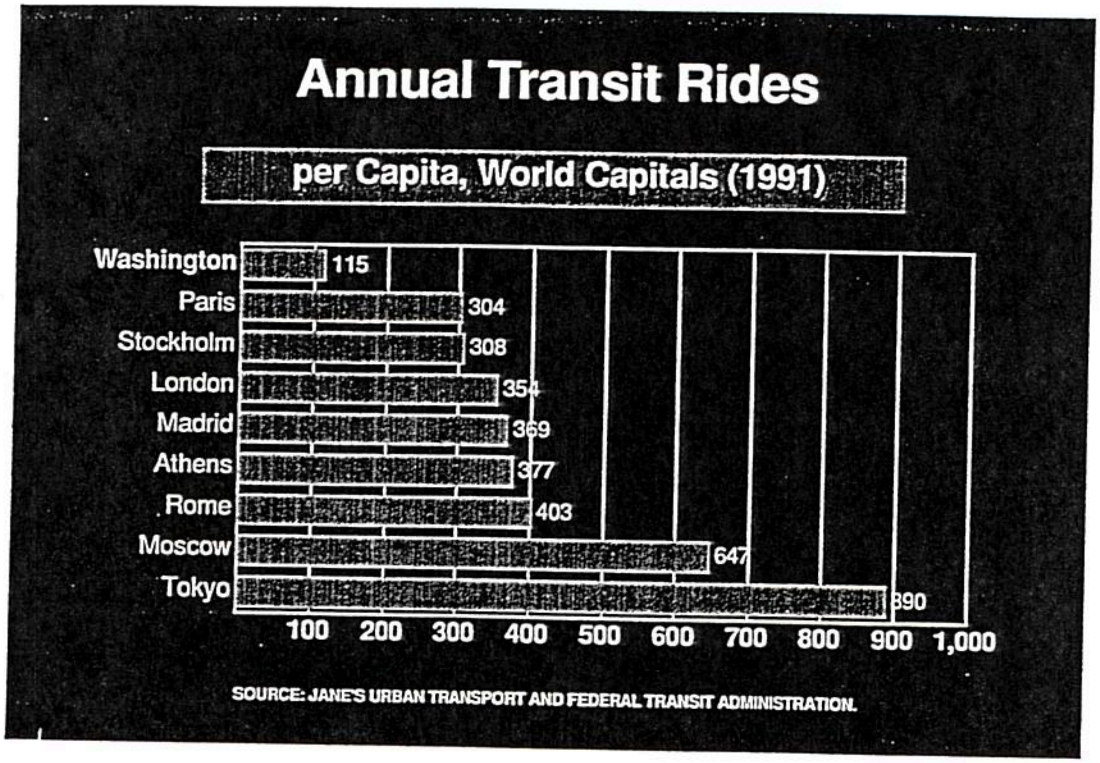


You may recall the strong opposition we had to the nickel gas tax increase back in 1990. Americans were up in arms over this very modest increase in our already low gas tax. If one considers the cost that Americans pay for auto insurance and depreciation as if they paid them at the pump, it would cost $3.31 per gallon. By comparison, the nickel increase is really rather minuscule. The problem is that drivers do not consider the insurance and depreciation expenses on a cost per trip basis. As a result, these costs are not properly factored in to the average driver's economic analysis of driving. They are fixed costs and are not usually taken into account as costs assigned to VMT or specific discretionary trips.

The President of a conservative think tank, concluded that if we were to assign the full market costs of both modes to autos and transit, we would see a marked increase in transit use, an improvement in the economic viability of transit, and reduction in auto use.



Our tax laws allow employers to provide transit pass benefits and parking benefits on a tax free basis however, transit benefits are capped at $60 while parking benefits are capped at $155 per month. Until the recent Energy Bill was passed, transit benefits were capped at only $21 and there was no limit on parking benefits. Although we have taken a step in the right direction, there is still a vast chasm in the treatment of the two modes. This inequity runs against the grain of the Clean Air Act and the Intermodal Surface Transportation Efficiency Act.



This chart reflects the inevitable result of our nation's policies--the number of transit rides per capita is the lowest in the U.S. capital when compared to other world capital cities.

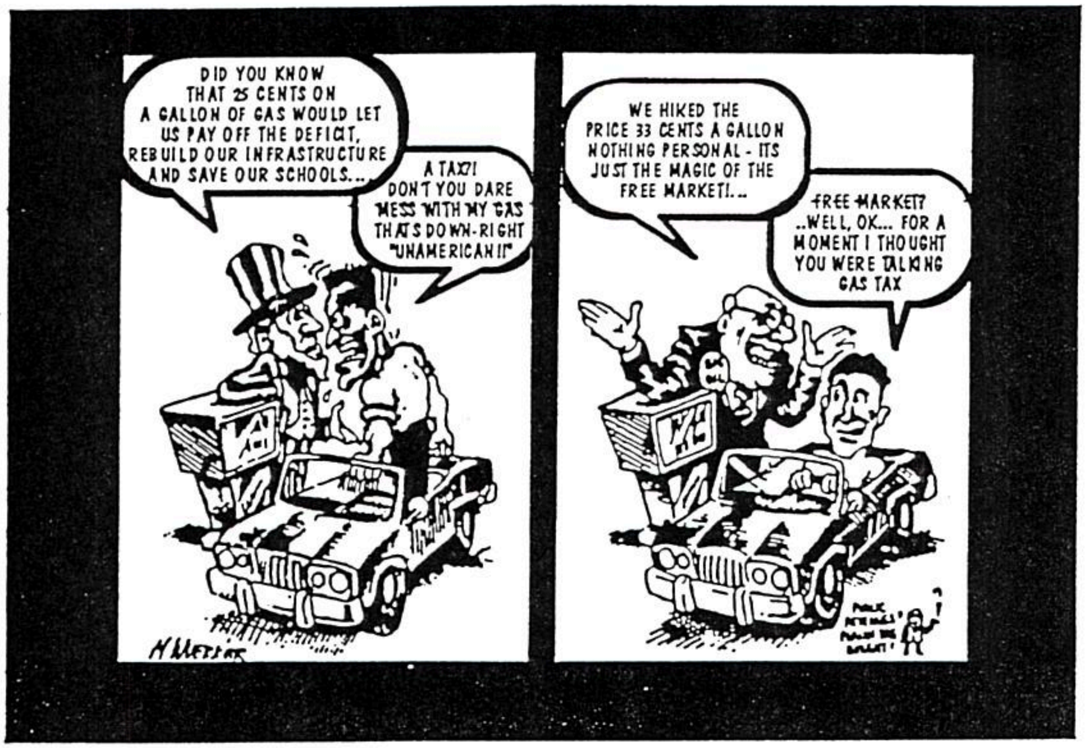
With all of the incentives to drive an automobile to work in this country--cheap gas, hidden subsidies, growth in federal aid for highways, decline in federal aid for transit, and high employer parking subsidy benefits--it is no wonder that transit ridership in the U.S. lags well behind the levels of other cities in Europe and Japan.

Cartoon Series

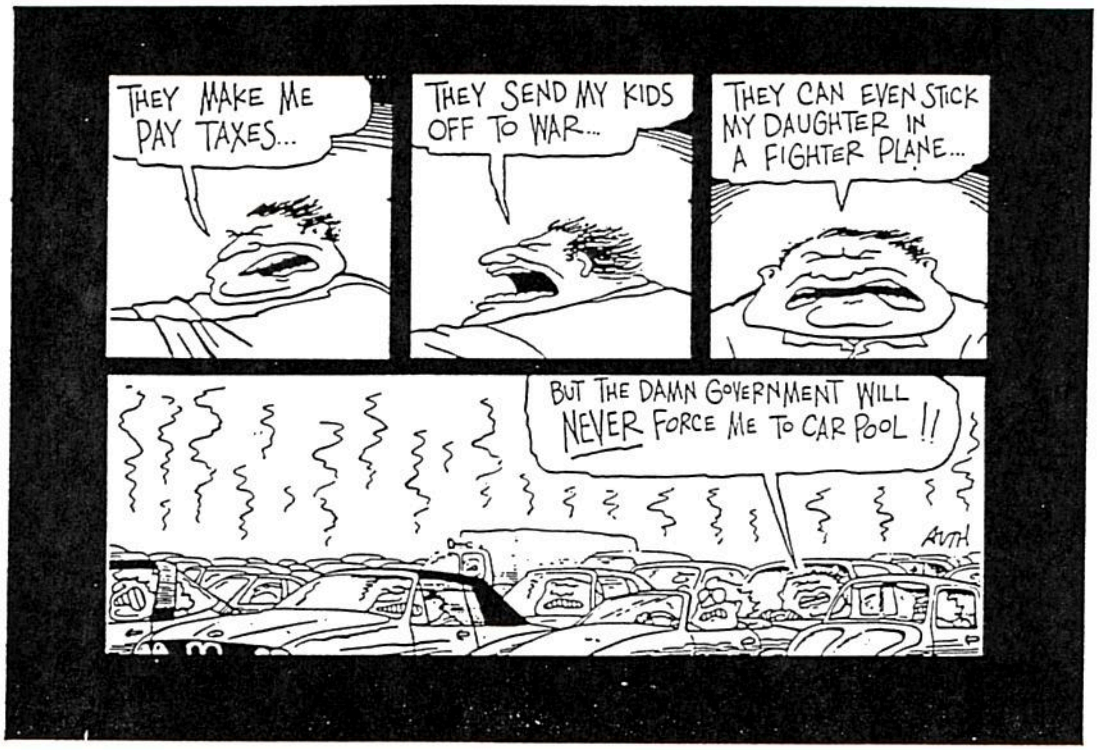
The following three cartoons provide stark insight into some deep rooted problems and important issues:

Miami Herald, Jim Morin

This cartoon is a bit dated but its message still holds true. It shows the reaction of many Americans when confronted with our vulnerability to instability in the Middle East. When a citizen suggests that we sock it to "that mad tyrant Hussein," by driving less and using public transportation more, the other pleads, "Couldn't we just nuke 'em?" Here we see the American tendency to look for a simplistic solution to a complex problem.

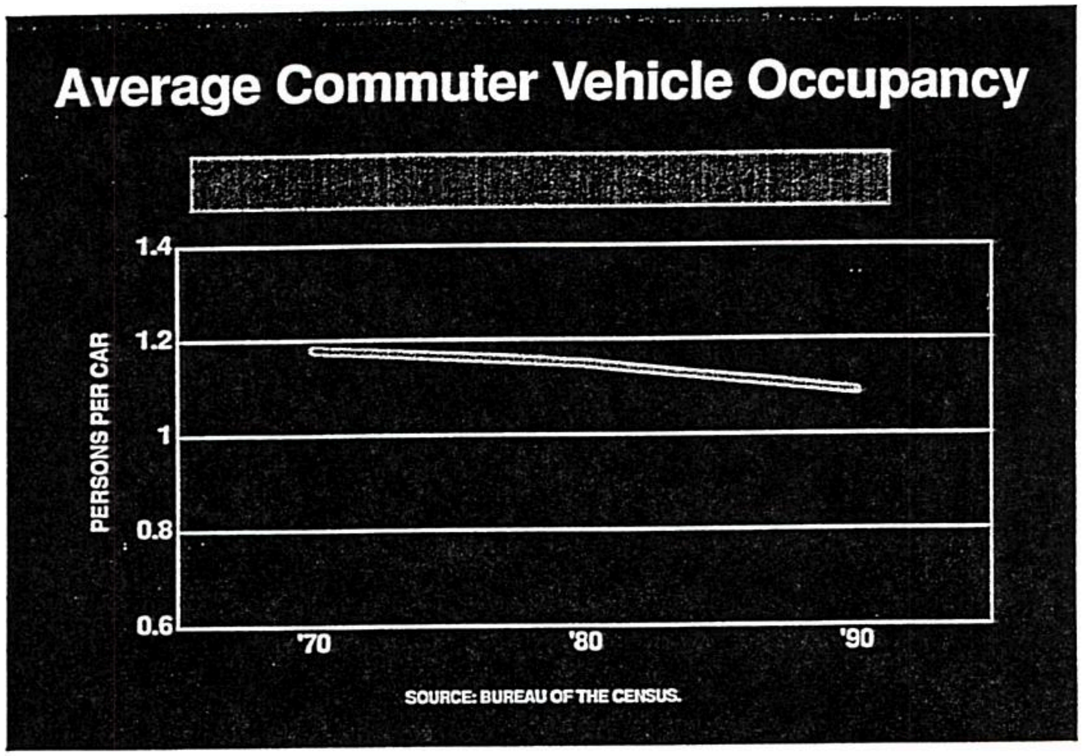


In this cartoon, the driver is furious when faced with a proposal to raise gasoline taxes 25 cents per gallon in order to pay off the deficit, rebuild our infrastructure, and save our schools. But when learning that it was not a tax but the magic of the free market that hiked the price of gas 35 cents, the driver is docile. This dialogue captures Americans' irrational and intense hatred for gas taxes.

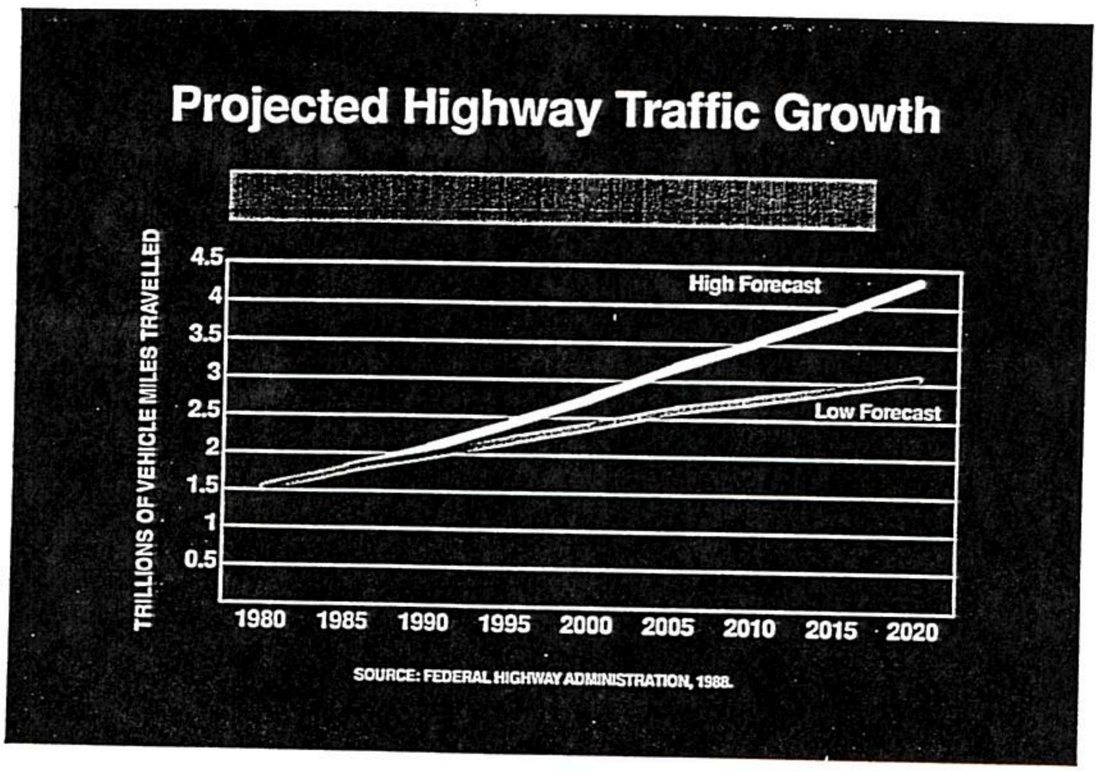


Philadelphia Inquirer, Tony Auth

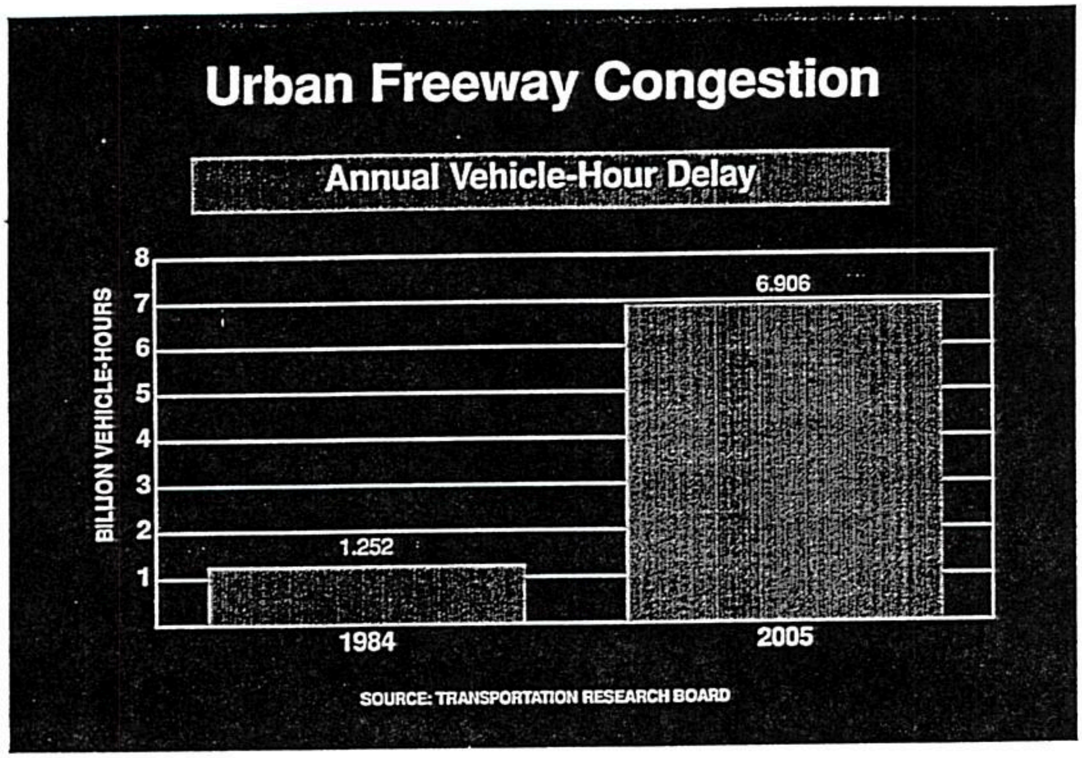
This cartoon captures our resistance to behavioral change.



One would think that in light of the trends such as the oil shocks of the 1970s and our preoccupation with energy conservation, that we would try to improve the efficiency of auto travel. However, we are seeing just the opposite--during the period from 1970-1990, average vehicle occupancy for journey-to-work trips declined from 1.2 persons per car to 1.1 persons per car. The notion of "one person-one car" is nearly a reality. Our national policies have encouraged the use of the single-occupant automobile.



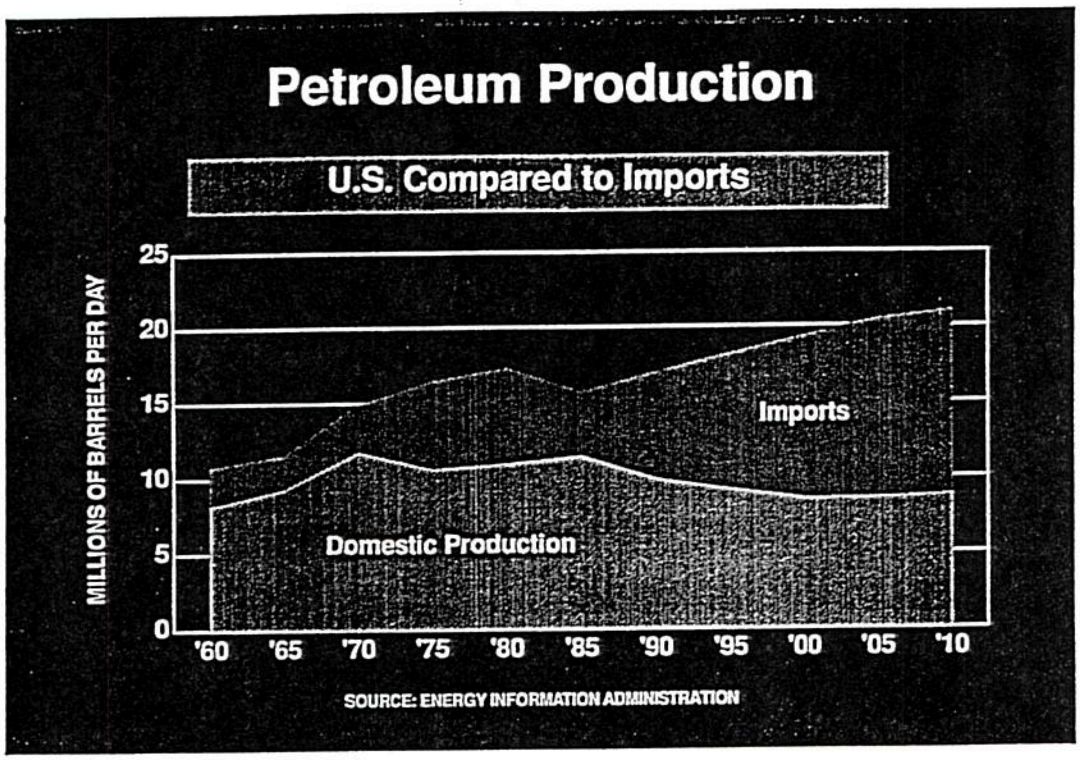
If we continue on the path we are on, traffic congestion will worsen and everyone's mobility will be compromised. The current low forecast indicates that vehicle miles traveled (VMT) will double in 27 years. It took almost a century to reach today's congested levels. The high forecast predicts that VMT will triple during that same time period. In 1990, actual miles driven by cars and trucks had already surpassed the projections made just two years earlier.



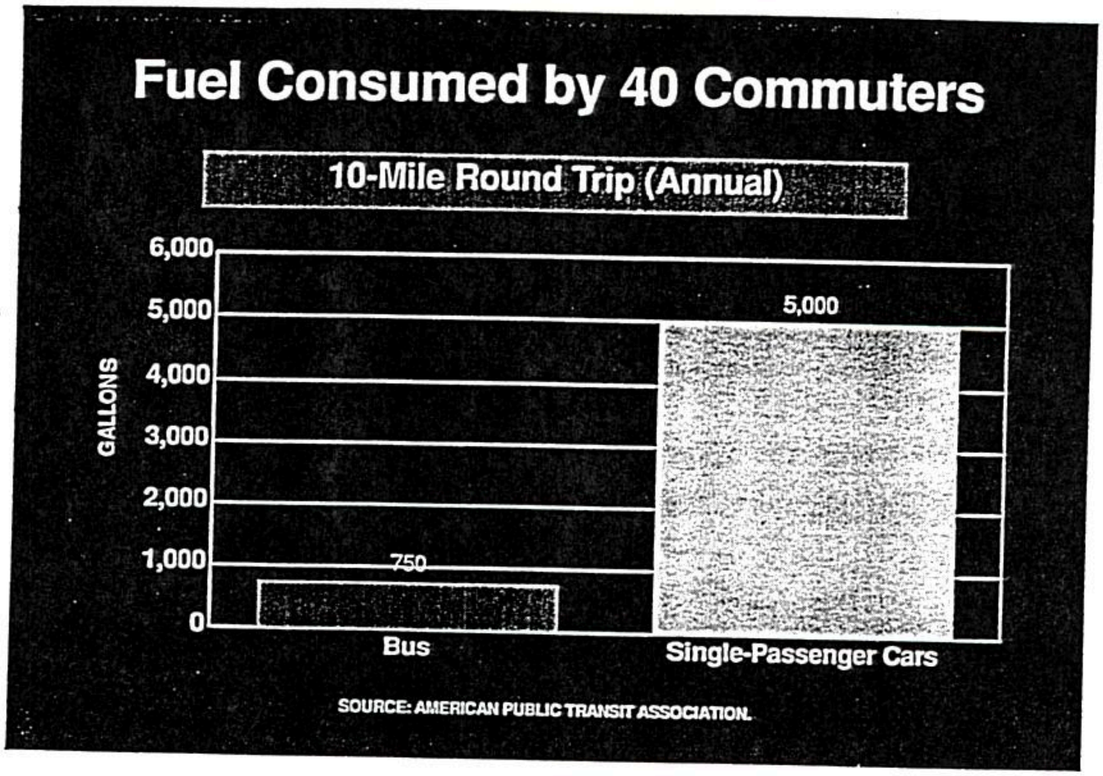
By the year 2005, delays due to congestion will increase more than five-fold. A worker entering the U.S. workforce today can look forward to spending two years of his work life stuck in traffic.

We are already witnessing this "congestion phenomenon." Many news reports are bringing home the same message: highway congestion is a terrible and worsening problem while transit ridership is stagnant, at best, and in many areas is on a downward spiral.

A new Philadelphia Highway called the Blue Route already carries more traffic than it was projected to carry 20 years from now. At the same time, transit ridership in the Philadelphia region is down. But can any other result be expected when driving is cheap, parking is free and highways are funded at far faster levels of growth than transit?



We have failed to grapple with the problem of our growing dependence on imported oil. Currently 50% of our transportation energy is imported and the percentage continues to rise. We spend some $50 billion per year on foreign oil which is the equivalent of a 50 cent gas tax; this money is permanently lost to our society and cannot be reinvested in infrastructure, education, research and development or retraining our workforce.



This chart shows the fuel efficiency of transit use. Annually, commuters who ride a bus in lieu of driving their cars, consume only 750 gallons of gasoline versus the 5,000 gallons of gas they would have used if they had driven to work.